Solar Neutrino Results from the Salt Phase of the Sudbury Neutrino Observatory

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The Sudbury Neutrino Observatory collaboration recently released the results on the analysis of the 391-live-day data set from its second (salt) phase [1]. Our group made several significant contributions to these new results on the solar neutrino flux, electron energy spectrum from $\nu - d$ charged-current (CC) and $\nu - e$ elastic scattering interactions, and on the asymmetry in the day and night solar neutrino fluxes. Analyses of this data set employed an electron kinetic energy $T_{\rm eff}$ threshold of 5.5 MeV, and the fiducial volume is restricted to the innermost 550 cm of the D_2O target volume.

The solar neutrino analysis was performed by fitting the event radial, angular correlation to the Sun and the light isotropy (event topology) distributions to those predicted by Monte Carlo (MC) simulations. The MC model used have been extensively calibrated by a variety of calibration sources. No assumption of the underlying neutrino energy spectrum was assumed in this "unconstrained" analysis. This is equivalent to not making any assumption on the energy dependence of leptonic flavor transformation.

Figure 1 shows the extracted CC $T_{\rm eff}$ spectrum compared to that predicted by the best-fit LMA parameters of $(\Delta m^2,\theta)$=(8.0 $\times 10^{-5}$ eV^2, 33.9°). The ES spectrum was extracted in a similar manner. In this spectrum analysis, the energy differential systematic uncertainties have been extensively evaluated with calibration source data.

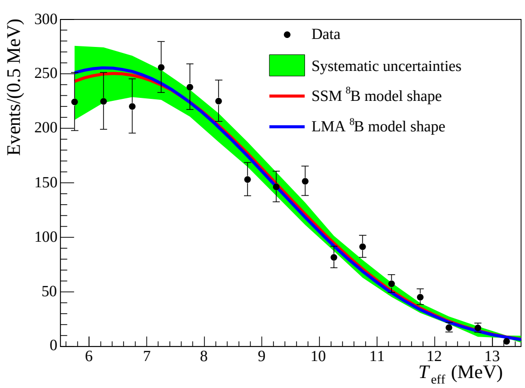

FIG. 1: Extracted CC $T_{\rm eff}$ spectrum compared to that predicted with the best-fit LMA parameters. Only statistical uncertainties are shown in the data spectrum. The band on the undistorted ^{8}B model shape represents the 1σ uncertainty determined from detector systematic uncertainties. The predicted spectrum is normalized to the same number of counts as the data spectrum. Note that the data points, especially the first three points, are statistically correlated as well as having correlated systematics as indicated by the error band.

For the unconstrained analysis, the quoted CC and ES fluxes are the equivalent fluxes of ^{8}B electron-neutrinos, assuming an undistorted ^{8}B energy spectral shape, that would produce the same CC and ES event rates above the analysis threshold of $T_{\rm eff} = 5.5$ MeV. For the NC case, the quoted flux is the flux of all active neutrino types that would produce the same NC rate above the reaction threshold of 2.2 MeV. The fitted numbers of events give the equivalent ^{8}B fluxes (in units of 10^6 cm^{-2}s^{-1})

$$\phi_{\rm CC}^{\rm uncon} = 1.68^{+0.06}_{-0.06}({\rm stat})^{+0.08}_{-0.09}({\rm syst}) \quad (1)$$

$$\phi_{\rm ES}^{\rm uncon} = 2.35^{+0.22}_{-0.22}({\rm stat})^{+0.15}_{-0.15}({\rm syst}) \quad (2)$$

$$\phi_{\rm NC}^{\rm uncon} = 4.94^{+0.21}_{-0.21}({\rm stat})^{+0.38}_{-0.34}({\rm syst}) \,, \quad (3)$$

and the ratios of the CC flux to NC and ES respectively are

$$\frac{\phi_{\rm CC}^{\rm uncon}}{\phi_{\rm NC}^{\rm uncon}} = 0.340 \pm 0.023\,({\rm stat})\,^{+0.029}_{-0.031}\,({\rm syst})$$

$$\frac{\phi_{\rm CC}^{\rm uncon}}{\phi_{\rm ES}^{\rm uncon}} = 0.712 \pm 0.075\,({\rm stat})\,^{+0.045}_{-0.044}\,({\rm syst}).$$

These results agree with the energy-constrained results from the pure D_2O phase of the experiment, and verify the Standard Solar Model predictions of the total active solar neutrino flux [2, 3]. Future improvements in the CC-to-NC ratio in the NCD phase will further constrain the mixing angle θ.

The day-night flux asymmetry parameter is defined as

$$A = \frac{\phi_{Night} - \phi_{Day}}{(\phi_{Night} + \phi_{Day})/2} \quad (4)$$

. In this analysis, the neutral-current day-night flux asymmetry ($A_{\rm NC}$) can be constrained to 0 in order to get the best estimate of the day-night asymmetry of the solar ν_e flux under the assumption of standard neutrino oscillations. Under the energy-unconstrained and $A_{\rm NC} = 0$ scenario, the day-night asymmetry of the CC and the ES fluxes are

$$\text{CC} : -0.037 \pm 0.063({\rm stat}) \pm 0.032({\rm syst}) \quad (5)$$

$$\text{ES} : 0.153 \pm 0.198({\rm stat}) \pm 0.030({\rm syst}) \quad (6)$$

The day-night asymmetry measurement is currently statistically limited.

[1] B. Aharmim *et al.* [SNO Collaboration], arXiv:nucl-ex/0502021.
[2] J. N. Bahcall, A. M. Serenelli, and S. Basu, astro-ph/0412440.
[3] S. Turck-Chièze *et al.*, Phys. Rev. Lett. **93**, 221102 (2004).